Indian J.Sci.Res. 17 (1): 302-307, 2017 ISSN: 0976-2876 (Print)
ISSN: 2250-0138 (Online)

TESTING OF VALUE AT RISK AND GENERALIZED AUTOREGRESSIVE CONDITIONAL HETEROSKEDASTICITY IN CURRENCY EXCHANGE RATE IN INDONESIA ECONOMIC CRISIS IN 2005, 2008 AND 2010

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ABSTRACT

The purpose of this research is to examine Generalized autoregressive conditional heteroskedasticity (GARCH) and Value at risk (VaR) model to predict future risks. This study uses backtesting test with Kupiec criterion that aims to test whether the Var wirh GARCH model is appropriately applied to calculate risk during economic crisis in 2005, 2008, and 2010. Finding from this research shows that GARCH and VaR models are not appropriate to be applied in managing risk during economic crisis in 2005, 2008, and 2010 by using 95% confidence level and 99% confidence level.

KEYWORDS: Risks, GARCH, Value at Risk, Kupiec Criteria

Risk can be interpreted as a form of uncertainty about a situation that will occur (future) with a decision taken based on various considerations at this time. The uncertainty of the middle exchange rate of US dollar movement to rupiah affects economy, especially for the economic crisis as one of the risks that occurred. One consequence of the risk is that asset value can be lost. This makes investors and policy makers in financial sector more prudent in protecting their asset values.

The economic crisis in 1998 made rupiah become uncontrollable and it caused severe impacts on the economy in 2005, 2008 and 2010. In addition, the effects of the economic crisis in the previous year made people worried so that many people drew their money massively and made the money circulation decline. This was also caused by the effects of the Dow Jones' flash crash in 2010. As a result, the exchange rates in 2005, 2008 and 2010 experienced extreme fluctuation and resulted in a loss of asset value. Therefore, it is important for the investors and decision makers in the financial field to calculate the risks that arouse so that the loss of assets can be minimized.

From many available risk measurement methods, VaR is the most method which is widely used in risk measurement because it combines the benefits of former risk measurement methods. The implementation of VaR method is a part of risk management. Investors can use the value of VaR as one of the benchmarks to determine how big the risk target in the future. VaR itself can be interpreted as the maximum loss estimation that will be obtained for a certain period of time (time period) in normal market conditions at a certain level of trust (trust level). Simply put, VaR is hoped to answer the question "how big (in percentage or a certain amount of money) investors can lose during investment time t with level of trust (1-α)". According Jorion (2007: 108) Value at Risk is the measurement of the worst loss of expectation in normal market conditions at time period T with a certain level of trust α.

However, before determining the VaR value, it is necessary to forecast the future and one of the forecasting methods that can be used is Generalized Autoregressive Conditional Heteroskedasticity (GARCH). Bollerslev developed a model known as Generalized Autoregressive Conditional Heteroskedasticity (GARCH) or also referred as the ARCH model development but it is a more efficient model than the ARCH. This method provided the best overall results by considering the number of exceptions and the time exceptions. The GARCH model is able to model the volatility of clustering in time series data well and is widely applied to various fields, particularly financial economics.

In addition, to test the validity of this VaR, it is conducted a test called a backtesting test. Backtesting is a formal statistical framework consisting of verification that the actual losses are in line with the projected losses. Backtesting studies are used to determine whether risk models can function effectively in volatile markets or quiet markets, and if so, which risk model performs best. To verify the accuracy of this model is by recording the failure rate that gives the proportion of times VaR which is exceeded in the sample given by using the Kupiec Method. The advantage of the Kupiec method is to know the accuracy of VaR model in projecting its potential loss by comparing actual return with daily VaR. If the proportion of VaR model error does not match the Kupiec Criteria table then the model is considered invalid.

Therefore, this study will examine the scale of VaR that arose during the economic crisis in 2005, 2008, and 2010 and test whether the GARCH model is

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appropriate to be applied to calculate VaR during the economic crisis in 2005, 2008, and 2010.

LITERATURE REVIEW

"Risk can be interpreted as a form of uncertainty of a situation that will occur (future) with a decision taken based on various considerations at this time. "(Fahmi, 2010: 174). According Jorion (2007: 108) Value at Risk is the measurement of the worst loss of expectation in normal market conditions at time period T with a certain level of trust α. There are three main methods to calculate VaR, the parametric method (also called the Varian-Covariance method), Monte Carlo Simulation method and Historical simulation. The three methods have their own characteristics. The Varian-Covariance Method assumes that normal distributed returns and portfolio returns are linear to the return of their single assets. VaR with the Monte Carlo Simulation method assumes that the portfolio return is not linear to the return of its single assets. VaR with Historical Simulation is a method that overrides the assumption of normal distributed return as well as the linear nature of the return of the portfolio to the return of its single assets.The difference of the three main methods for calculating VaR can be seen in Table 1.

Table 1: The Differences of VaR Method

Risk Factor Distribution	Valuation Method	
	Local Valuation	Full Valuation
Analytical	Delta-normal	Not Used
	Delta-gamma-delta	
Simulated	Delta-gamma-monte-Carlo	Monte Carlo
		Grid Monte Carlo
		Historical

Source: Jorion (2007:257)

Assume portfolio capital of $ 100 million for 10 days with 99% trust degree. The steps in VaR calculation are as follows.

1. Focus on the market that is to current portfolio value (as a sample, $100 million).
2. Calculate the risk variability (as a sample, 15%).
3. Determine the time period, it can be seen from holding period (as a sample, 10 trading days).
4. Determine the trust degree (for example, 99% with z = 2.33, assume normal distribution)
5. Calculate the worst loss, so that VaR value is obtained as follow.

$$\text{VaR} = \$100\text{M} \times 15\% \times \sqrt{\left(\frac{10}{252}\right)} \times 2.33 = \$7\text{M} \qquad (1)$$

However, before determining the VaR value, it is necessary to forecast the future and one of the forecasting methods that can be used is Generalized Autoregressive Conditional Heteroskedasticity (GARCH). Bollerslev developed a model known as Generalized Autoregressive Conditional Heteroskedasticity (GARCH) or also referred as the ARCH model development but it is a more efficient model than the ARCH.

The generalized autoregressive conditional heteroskedastic (GARCH) model was introduced by Engle (1982) and Bollerslev (1986). Heteroskedastic relates to the fact of variation change. The GARCH model assumes that variations of return are followed by unpredictable processes. The conditional variation does not only depend on the last variation but also depend on the previous conditional variation. The GARCH model has become a time series analysis tool of financial markets that describes volatility grouping systematically. The drawback of this GARCH model is the lack of linearity of the model. The parameters used are estimated with the maximum function which consists of the optimization of numbers "(Jorion, 2007: 223).

After forecasting by GARCH and calculating of risk value by VaR model done, then Backtesting is proceeded. According to Jorion (2007: 139), backtesting is a formal statistical framework consisting of verification that actual loss is in line with forecast loss.Backtesting is done by comparing the actual daily profit / loss that occurs with the daily VaR value. If the actual profit / loss is greater than VaR, then the result of VaR on that day is considered failure or it does not follow the actual events that occurred on that day. The total number of failures for each issuer is calculated and then entered into the Total Failure (TF) equation created by Kupiec. The amount of data from the comparable variable must be at least 252 (two hundred and fifty two) observation days. After that, see Kupiec Criteria Table, which can be seen in Table 2.

Table 2: Total Failure According to Kupiec Criteria

Probability	VaR Confidence Level c	Nonrejection region for number of failures N		
		T=252 days	T=510 days	T=1000 days
0.05	95%	6 < N < 20	16 < N < 36	37 < N < 65
0.01	99%	N < 7	1 < N< 11	4 < N < 17

Source: Jorion (2007:146)

Timotheos Angelidis, Alexandros Benos and Stavros Degiannakis (2004) research entitled "The Use of GARCH Models in VaR Estimation" study results indicate that the GARCH model fails to measure the volatility of stocks and indicates that the combination of Student-t distribution with GARCH models are better used in forecasting the volatility caused in the stock market.

D Ng Cheong Vee, P Nunkoo Gonpot and N Sookia (2011) research entitled "Forecasting Volatility of USD/MUR Exchange Rate Using a GARCH (1,1) Model with GED and Student's Errors" study results show that the GARCH model With the distribution of GED and Student's t errors suitable to predict the volatility arising from the US dollar exchange rate.

Md. Zahangir Alam and Azizur Rahman (2012) research entitled "Modeling Volatility of the BDT / USD Exchange Rate with GARCH Model" study results indicate that the GARCH model fails to be used to measure the volatility caused by the exchange rate and also indicates that the EGARCH and TARCH models become The best model in measuring exchange volatility.

Y. M. Wong, R. Ahmad and M. Ariff(2014), research entitled "Exchange Rate Responses to Macroeconomic Surprises: Evidence from the Asia-Pacific Markets" also conducted the same research by making the Asia Pacific market an object of research. The results of this study indicate that there are risks arising from the volatility of exchange rates and states that there are influence of economic factors and the Fed's policy on the uncertainty of currency exchange rates that occur in the Asia Pacific market.

Research conducted by Anne-Marie-Gulde-Wolf (2016) also states that the uncertainty of the movement of currency values also occurred in South Africa, political uncertainty and economy caused the financial crisis in South Africa so, it was conducted a study by VaR method to control Risks arising from the movement of currency values in Africa.

Jason Narsoo's research (2016) entitled "Evaluation of GARCH-Type Models in Volatility and Value at Risk Forecasting: Evidences from USD / MUR Exchange Rates" states that with 99% trust level, the GARCH model is suitable to predict the potential risks caused by the movement of the USD / MUR exchange rate. Another study was also conducted by Manamba Epaphra (2017), which calculates the scale of risk due to exchange rate movements by using VaR, it is only the study compares two estimates contained in VaR namely Autoregressive Conditional Heteroskedasticity-Generalized Autoregressive Conditional Heteroskedasticity (ARCH-GARCH) And Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH).

Samir Mabrouk research (2017) entitled "Volatility Modeling and Parametric Value at Risk Forecast Accuracy: Evidence from Metal Products" shows that the GARCH model fails to measure volatility caused by metal prices and shows that the Student-t model with the model FIAPARCH can be used to measure the volatility of asymmetric data of metals in the long term.

METHODOLOGY

This research use data USD/IDR from Bank Indonesia and use judgement sampling. Samples are adjusted for high volatile and samples that choosen are USD/IDR in 2005, 2008, and 2010. The process of this research is obtained as follow.

1. Determine the samples of research (as samples; USD/IDR in 2005, 2008, and 2010)
2. Calculate and forecast standard deviation by GARCH model
3. Determine the trust degree (as samples, trust degree 99% and 95%)
4. Calculate VaR value
5. Do backtesting test by Kupiec Criteria

RESULTS AND DISCUSSION

The GARCH model is used to predict future risks while the VaR model can estimate the maximum loss to be earned over a given time period and level of trust. This study uses 735 daily historical data of US dollar exchange rate against rupiah during the research period in 2005, 2008, and 2010 where the amount of each daily historical data are 245, 242, and 248 observed.

In accordance with the Basel Committee provisions in Jorion (2007) and Attachment of Bank Indonesia Circular Letter (2011), the time horizon used in the VaR calculation is 10 trading days while the degree of trust used is 95% and 99%. Calculation of VaR model can be processed by using the following equation.

$$VaR = V_0 x \sigma x \propto x \sqrt{t} \quad (2)$$

Suppose the average value per 10 working days from January 3 to January 14, 2005 period is 9,305, the standard deviation (σ) is 0.002811903, the time horizon (t) is 10 trading days with the number of days per year = 252, the degree of trust is 95% with the value of (∝ or z) = 1.645 so the calculation of value at risk as follows.

$$\text{VaR}(95\%)_{3\text{January }2005} =$$

$$9{,}305 \text{ x } 1.645 \text{ x} 0.002811903 \text{x} \sqrt{\frac{10}{252}} = 10.2158 \qquad (3)$$

The above calculation results indicate that the potential maximum loss is acceptable for IDR 10.2158 for 10 trading days with investment amount IDR 9,305. After the calculation of VaR, then backtesting test is conducted by comparing actual return with daily VaR. If the actual return is greater than VaR, then it is calculated as failure, and vice versa. Then, calculate the number of failures and match the Kupiec Table. If the number of failures exceeds the number of failures in the Kupiec Criteria, a new model is needed to calculate the risks during the economic crisis in 2005. The same steps are also used to calculate and test models in 2008 and 2010. Kupiec criteria and research results using GARCH and VaR in 2005, 2008, and 2010 can be seen in Table 3.

Table 3: Kupiec Criteria and Research Results Using GARCH and VaR for the Years 2005, 2008, and 2010

Probability leve, p	VaR confidence level, c	Nonrejection region for number of failure, N	Total failure			Conclusion		
		Kupiec Criteria	2005	2008	2010	2005	2008	2010
0.05	95%	6 < N < 20	151	161	181	Rejected	Rejected	Rejected
0.01	99%	N < 7	145	156	172	Rejected	Rejected	Rejected

Source: processed data

Table 3 shows that the total failure in 2005, 2008, and 2010 exceeded the limit of the number of criteria kupiec failure either using 95% or 99% degree of trust. This shows that the hypothesis H_{01}, H_{02}, H_{03}, H_{04}, H_{05}, and H_{06} are rejected which means that the GARCH and VaR model with 95% and 99% trust degree cannot be applied to calculate the risk of currency volatility during the economic crisis in Indonesia.

GARCH as symmetric volatility forecasting assumes symmetrical shocks to volatility which means the GARCH model assumes that variations of return are followed by unpredictable process. GARCH also sees errors and variants from previous data. The economic crisis in 1998 made the rupiah uncontrollable and caused severe impacts in 2005, 2008 and 2010. In addition, the additional effects caused by Dow Jones flash crash in 2010 created a very extreme exchange rate shocks. Massively extreme exchange shock makes GARCH, a forecasting model that will be used as a step in measuring risk in which VaR fails to be applied to calculate risks arising from currency movements during the economic crisis in Indonesia in 2005, 2008, and 2010. This is because the GARCH model uses assumptions that can be applied only on non extreme shock condition.

The results of this study are also supported by previous research where the results can be seen as follows.

1. Timotheos Angelidis, Alexandros Benos and Stavros Degiannakis (2004) under the title "The Use of GARCH Models in VaR Estimation" shows that the GARCH model fails to measure volatility generated from stocks and indicates that the combination of Student-t distribution with GARCH model is better used in forecasting the volatility caused by the stock market shock during economic crisis.
2. Md. Zahangir Alam and Azizur Rahman (2012) under the title "Modeling Volatility of the BDT / USD Exchange Rate with GARCH Model" finds that the GARCH model fails to be used to measure the volatility caused by the exchange rate and also indicates that the EGARCH and TARCH models become The best model for measuring currency volatility during economic crisis.
3. Samir Mabrouk (2017) entitled "Volatility Modeling and Parametric Value at Risk Forecast Accuracy: Evidence from Metal Products" shows that the GARCH model fails to be used to measure the volatility caused by metal prices and show that the Student-t model with the model FIAPARCH can be used to measure the volatility of asymmetric data of metals in the long term.

Based on the results of the research conducted and the results of previous research, it is found that the GARCH model can only be used to measure the risk under a non extreme shock condition. It cannot be applied

under an extreme shock condition as during economic crisis. Therefore, it is suggested to use GARCH derivatives such as TARCH, FIAPARCH, etc. to measure the risks inflicted by extreme shocks such as shocks during economic crisis.

CONCLUSION AND SUGGESTION

The conclusions of this study are as follows.

1. Based on the result of volatility forecasting using Generalized Autoregressive conditional heteroskedasticity (GARCH) method, the value of volatility in 2005 is 0.002811903, in 2008 is 0.000731691, and in 2010 is 0.0000000704.
2. Based on the result of backtesting test in 2005 by degree of trust 95%, hence it is obtained the total failure in 2005 by degree of trust 95% is 151 failure. This shows that 95% trust degree cannot be applied to calculate VaR value that happened due to currency volatility during the economic crisis in Indonesia in 2005.
3. Based on the backtesting test result in 2005 with 99% trust degree, hence it is obtained the total failure in 2005 by trust degree 99% is 145 failure. This shows that 99% trust degree cannot be applied to calculate VaR value that happened due to currency volatility during the economic crisis in Indonesia in 2005.
4. Based on the backtesting test result in 2008 by degree of trust 95%, hence it is obtained the total failure in 2008 by degree of trust 95% is 161 failure.This shows that 95% trust degree cannot be applied to calculate VaR value that happened due to currency volatility during the economic crisis in Indonesia in 2008.
5. Based on the backtesting test result in 2008 by degree of trust 99%, hence it is obtained the total failure in 2008 by degree of trust 99% is 156 failure. This shows that 99% trust degree cannot be applied to calculate VaR value that happened due to currency volatility during the economic crisis in Indonesia in 2008.
6. Based on the backtesting test results in 2010 by 95% trust degree, then it ia obtained the total failure in 2010 by 95% trust degree is 181 failure.This shows that 95% trust degree cannot be applied to calculate VaR value that happened due to currency volatility during the economic crisis in Indonesia in 2010.
7. Based on the backtesting test results in 2010 by 99% trust degree, then it is obtained the total failure in 2010 by 99% trust degree is 172 failure. This shows that 99% trust degree cannot be applied to calculate VaR value which happened due to currency volatility during the economic crisis in Indonesia in 2010.
8. Based on the calculation result by using Generalized autoregressive conditional heteroskedasticity (GARCH) and Value at risk (VaR) method, it is found that GARCH and VaR model cannot be applied to calculate the risk caused by currency volatility during the economic crisis in Indonesia.

The suggestions from the results of this study are for practitioners, GARCH model or GARCH and VaR derivatives can be used for recommendations and references for investors and financial decision makers in calculating the profit and loss (risk) of the US dollar application on extreme currency shocks and derivative models GARCH and VaR can be used on exchange rate shocks To the extreme so as to minimize the risk of loss of asset value. In addition, for decision makers in the field of finance and investors, to be careful in making decisions such as when it will invest money in times of economic crisis and when there is a very extreme economic shocks.

The suggestions for the next researchers, GARCH and VaR model with degree of trust 95% can be used as input and reference for next research. However, further research can also use other GARCH derivative models such as EGARCH, etc., VaR with degree of trust 95% and 99% confidence level, and can be applied to calculate the value of other currency exchange risks.

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